Preliminary Watershed Assessment

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Complexity	Value as a Planning Tool	Cost
Low – Moderate – High	Low – Moderate – High	Low – Moderate – High

OVERVIEW

Much has been said about the need to use "holistic" perspectives that consider the entire watershed when contemplating stream restoration options. Unfortunately, political, programmatic, and jurisdictional boundaries seldom correspond with watershed boundaries and restoration projects focus on specific sites. Without a comprehensive reach or watershed assessment, selected restoration measures often ignore underlying problems at a broader scale and are either ineffective or not cost-effective relative to other measures (Figure 1).

Figure 1. Watershed conditions can dictate processes that affect restoration potential in reaches far downstream

A reconnaissance and assessment of watershed character is necessary to:

- Assess watershed conditions to determine the causes and nature of impairment
- Determine feasibility of using restoration or other management options to meet objectives

In some cases, ecological restoration is the most effective response to impairment; in other cases, restoration may be one among many candidate tools for achieving objectives. To determine the appropriate actions, it is necessary to collect, compile, analyze, and interpret environmental data rapidly to facilitate management decisions and resultant options for preservation and control or mitigation of impairment. This technical note considers watershed and reach reconnaissance techniques that possess the following principal elements:

- Cost-effective
- Facilitate comparisons among sites
- Quick, yet scientifically valid
- Easily presented to the public
- Environmentally-benign procedures

RECONNAISSANCE OBJECTIVES

The goals of a watershed or stream reach reconnaissance can be stated many ways. Fundamentally, the objective of the effort should be to formulate a sufficient understanding of the ecosystem to allow informed decision making in selecting and designing management alternatives.

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Basic Site Characterization. Basic site characterization and data collection are the first steps in inventorying a watershed. Characterization may include information on water quality, geochemistry, hydrology, fluvial geomorphology, substrate condition, flora, and fauna, and, to the greatest extent possible, identification of stressor sources in the watershed. In addition to traditional point source loading of pollutants, stressors may include nonpoint source pollutant loading, land-use effects upon hydrology or sediment yield, physical habitat alterations, and invasion of non-native flora and fauna.

Data collected, including both site and landscape-scale data, also provide a baseline for evaluating the performance of restoration projects. These data can be used to establish environmental benchmarks to be used later to monitor for success of the restoration practices.

In addition to physical and chemical characteristics of the watershed, land ownership and regulatory jurisdictions play an important role in determining opportunities for restoration. Much of this information is geographically based, and amenable to storage and manipulation in a Geographic Information System. As part of the basic site characterization, the acquisition of historical and current data on landscape-scale habitat and land-use characteristics as well as land ownership is recommended. This information is useful for (1) setting realistic restoration goals, and (2) identifying regional issues that must be addressed before undertaking a watershed or site-specific restoration project.

Habitat Analysis. Analysis of habitats is important for identifying weaknesses and potential strengths in the habitat structure of the stream being considered for restoration. Regardless of the specific approach used, habitat assessment should:

- Facilitate identification of potentially limiting habitat conditions.
- Provide design guidance regarding "what works" from a habitat perspective in the type of stream being restored.
- Be repeatable to allow pre- and post-restoration comparison.

Habitat assessment should identify habitat deficiencies by surveying the project site and less degraded comparison or reference sites in the same geographic area. These surveys can be visual, qualitative estimates or can be based upon quantitative measurements. Assessments usually consider such key habitat variables as pool-riffle-run ratio, pool quality, predominant substrate type, substrate embeddedness, available cover, bank structure and stability, water temperature, riparian vegetation type and abundance, and riparian buffer widths.

Habitat assessment for more formal designs often requires quantitative measurements and statistical comparison of conditions at the sampled sites. Most state and federal resource management agencies have aquatic habitat evaluation procedures tailored to local and regional conditions, and may have file data available to assist in defining habitat restoration goals. While many evaluation procedures have been proposed, most of the methodologies fall into one of two general categories based on how habitat data are collected and analyzed. Basin-wide methodologies focus on habitat data collection and analysis on a reach-by-reach basis, frequently using numerical ratings to score specified attributes of habitat quality. Transect methodologies measure specific parameters along cross-section transects established in study reaches representative of longer stream segments.

Identify Nature of Impairment. In some watersheds, direct and predictable relations between watershed character and stream impairment exist. In many cases, however, the connection between sources and impairment is less obvious. A spatial analysis of the specific nature and causes of impairments throughout the watershed is usually not feasible during the watershed inventory. However, an overriding objective of the reconnaissance effort should be to identify and characterize as many cause-effect relations as possible. Major causes of degradation of stream habitat include dams and other water control structures, urbanization, clearing of vegetation along the streambank and immediately adjacent land, access of humans and wildlife to streambank with soil compaction and increased erosion, alteration of the composition of stream-side vegetation through reduction of plant cover, and river-management and transportation works including bank stabilization activities. These activities should be noted and qualitatively evaluated for their impact on available habitat.

Identified impairments must be addressed within the appropriate regulatory context. In some cases, a narrative criterion or designated-use component of the water quality standard may explicitly refer to a habitat use, such as the necessity of maintaining spawning habitat. In other cases, the water quality standard in question may not refer explicitly to a habitat goal or function, but rather to some numeric criterion. Restoration may thus address numeric or narrative criteria.

Combining information on watershed physical characteristics, water quality, habitat, land ownership, and regulatory jurisdictions with the preliminary analysis of the nature of impairment allows selection of the best strategies to develop sustainable restoration sites, increase regional biodiversity, and, along the way, suggest the places appropriate for economic development.

Establishing a Standard of Comparison. One of the more important (and difficult) tasks is the establishment of a reference condition that can serve as one of the following options: (1) A target or objective for the restoration project. (2) A standard for comparison among candidate sites. Restoration based upon replicating a reference condition (Option 1) requires the selection of a desired end condition for the proposed management action. A predetermined standard of comparison provides a benchmark against which to measure progress.

Option 2 is intended to serve as a basis for the relative comparison of degradation and restoration potential among candidate sites and, thus, needn't be a "desired" condition (see Figure 2). Project constraints, notably funding availability, generally preclude the implementation of all potential restoration or management options. A means of prioritization is very helpful in selecting sites within a watershed or along a stream reach for which the benefits will be greatest given project constraints.

Historic conditions in the region should be considered when establishing a standard of comparison. If current conditions in a stream corridor are degraded, the standard at a time period in the past that represented more natural or desired conditions should be used. Team members should agree on what conditions are desired prior to establishing the standard of comparison. In addition, the geographic location and size of the area should be considered. Patterns of diversity vary with geographic location, and larger areas are typically more diverse than smaller areas.

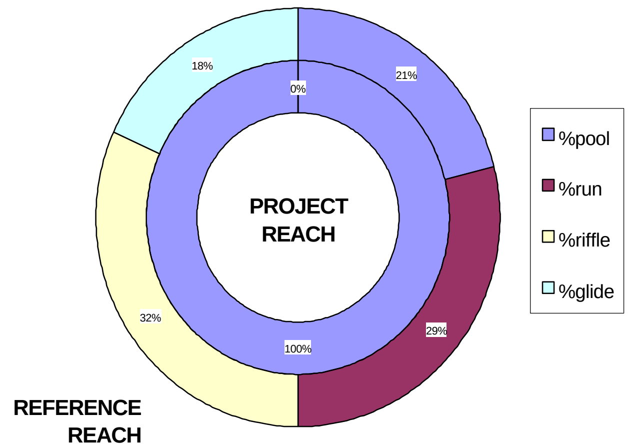

Figure 2. Comparing the habitat distribution of a project with that of a reference reach can help establish design objectives

Opportunities for Restoration. Even where good opportunities exist for ecological restoration, the team must establish whether or not such techniques are appropriate for further consideration as management options taking into account the technical feasibility of restoration. That is, there will be cases in which ecological restoration opportunities are obvious, yet are not technically feasible with the current state of the science.

When direct, instream ecological restoration does not appear feasible, riparian or upland restoration options (generally based on source control in the surrounding watershed) may improve habitat. When restoration by either instream, riparian, or upland techniques appears feasible, the goals for the project must be reevaluated. The economic viability of candidate restoration techniques should be considered during the reconnaissance.

EXAMPLE DATA COLLECTION EFFORTS

The author has participated in a number of watershed assessments with the express intent of identifying candidate sites for restoration or other management measures. To ensure consistency in these efforts, he has constructed field sheets for data compilation. Two general categories of data are collected in the reconnaissance efforts, (1) physical data characterizing the watershed, stream, and observed processes, and (2) a qualitative assessment of ecological character. The specific nature of the field data sheets varies by project, but the general form is similar among projects and they are presented here so the reader can adopt a similar strategy.

The strategy used is to divide the stream (and associated watershed) into distinct reaches. Separate data sheets are used for each reach. Factors used in the reach subdivision include:

- General stream character
- Stream stability
- Adjacent land use
- Property ownership
- Anthropogenic features
- Project objectives
- Riparian condition
- Location of tributaries
- Location of gauges
- Access and survey time

The example sheets presented in this technical note and the accompanying field descriptors were designed for a suburban watershed assessment in Georgia. Example results are from this project and
from an assessment in Alaska.

Physical Data Sheet Description. Appendix A presents an example form used to document the field conditions observed during the reconnaissance effort. A separate sheet is used for each study reach, and each data sheet includes a summary header section with the study reach denoted by stream name and reach number, starting and ending latitude and longitude, the date of the survey, gauge level on that date (if the stream is gauged), and the name of the surveyor. Check marks are provided for the surveyor's assessment of the verity of the reach as a reference. In addition to the data categories described below, space is provided on the sheets to record observations, sketches, and numbers of photographs taken of the subreach.

The first category of data evaluated on the sheet is the area and percent impervious surface in the watershed. These values can be determined using a GIS database.

Under the adjacent land-use heading are eight classifications. Land-use classification is based upon field observation during the reconnaissance survey with verification using aerial photographs. Land use is characterized only for a 100-m corridor landward of left and right top banks. For many of the subreaches, more than one adjacent land use may be noted. In these cases, estimates of the percent distribution of each class should be noted. A list of the classes and their descriptions follow.

Adjacent Land Use (within 100 m of top banks):

Wetland – Sedge-dominant or bottomland hardwood (BLH) riparian wetlands.
Forest – Predominantly timber.
Agriculture – Crops or pasture.
Parks and Recreation – Trails, golf courses, and parks.
Residential – Single-family dwellings or subdivision for lot sale.
Commercial/Industrial – Self explanatory.
Transportation – Roads, rail lines, and bridges.
Utility – Power, telephone, or pipeline right-of-way.

The third category addressed on the field notes is the type of riparian vegetation. Included are eight classes. Riparian vegetation classification is based upon field observation during the survey with verification using the aerial photographs. The classification is limited to the riparian and near overbank zone (about 30 m landward of the top bank). The overbank vegetation classification does not include vegetation below the top of bank. In most cases, percent distribution for each class in the reach should be estimated. The classifications used in these sheets are not proposed for use beyond the purpose of serving the immediate mapping activity. Much more field work and description of vegetation units will be necessary before a more nearly ideal classification can be devised and the areas appropriately classified. A list of the classes and their descriptions follow.

Riparian Vegetation (within 30 m of top banks):

- Barren - Soil, concrete, rock, or other surface absent any vegetation cover.
- Sedges and grasses - Carices or other graminoids dominant; water table at or above ground surface most of growing season; little or no peat accumulation. Does not include non-native herbaceous vegetation.
- BLH – Dominated by seasonally flooded hardwoods including *Quercus* and *Nyssa*.
- Shrubs – Low-growing woody vegetation of various native species combinations, including stands of young tree species of shrub size. Most shrub thickets in the study area are made up of broadleaf species, including orthophyllous deciduous species (willows (*Salix spp*.), alders (*Alnus spp*.), dogwoods (*Cornus spp*.), etc.)
- Deciduous forest – Predominantly broad-leaved trees such as oak (*Cornus spp*.), cottonwood (*Populus spp*.), elm (*Ulmus spp*.), etc., in closed- or somewhat open-canopy arrangement. Might include a few evergreen or shrub species but less than 10 percent of total area.
- Coniferous Forest – Predominantly pine (*Pinus taeda, P. echinada, P. virginiana*, etc.) trees in closed or somewhat open canopy arrangement. May include a few deciduous tree or shrub species but less than 10 percent of total area.
- Invasive – Nonnative nuisance vegetation including kudzu (*Pueraria lobata*) honeysuckle (*Lonicera spp*.), and privet (*Ligustrum spp*.).
- Nonnative - All nonnative herbaceous vegetation, including most lawns.

The next category is a descriptor of the vegetation cover characteristics in the reach and includes measures of percent canopy closure over the water and the percent large woody debris (LWD) in the reach.

The fifth category addresses channel characteristics. Included are the channel planform, the profile characteristics (as manifested in the flow conditions), the flow type, and other miscellaneous features that contribute to habitat. Most reaches include one or more meanders and, thus, considerable diversity in many of the channel characteristics. The intent of this effort is to provide some useful information in evaluating overall diversity of the reaches. Summary descriptions of the classifications for each category follow.

Channel Characteristics:

Planform - The general shape of the channel as viewed from above.

- Bend - A meander where the channel thalweg is against the outer bank.
- Crossing - A short straight reach between meanders with the thalweg not aligned with the banks.
- Straight - A long, relatively straight reach where the thalweg is generally parallel with the banks or where there is no discernible thalweg.

Profile - The longitudinal form of the channel; generally defined by the gradient. In this case, riffles, pools, and runs are used to differentiate between profile characteristics because channel slopes were not measured.

- Riffle - A reach with a relatively high width-to-depth ratio, no defined channel thalweg, and a generally higher gradient and velocity, lower depths, and coarser bed material than the mean channel conditions. Usually associated with crossings or straight reaches.
- Pool - A reach with a relatively low width-to-depth ratio, a well-defined channel thalweg along one bank, with generally lower gradients and velocities, greater depths, and finer bed material than the mean for the channel. Usually associated with meander bendways.
- Run - A reach comparable to a riffle except with a generally lower gradient and lower velocities. Can be associated with either straight reaches or gentle meanders.

Flow Type - A general category describing the flow energy of the system. For this study, only two classes apply (rapid and tranquil) and these are closely related to the profile.

- Rapid - High energy, relatively shallow, associated with riffles and high gradient meanders.

Tranquil - Low energy, fairly deep, associated with runs and low gradient meanders.

Features - A general category intended to capture the presence/absence of habitat features and diversity.

Bars - Deposits of sediment located within the channel margins that have a height in excess of the mean water level. Point bars are attached to the bank and associated with bendways, whereas mid bars are not attached to the banks and are generally found in straight reaches. Bars are either devoid of vegetation or have only sparse pioneer vegetation occupying less than 25 percent of the surface area of the feature.

Shoals - Deposits of sediment located within the channel margins that have a height less than the mean water level. Shoals are devoid of vegetation, and generally consist of sediments in the coarse sand to small cobble range.

Chutes/Backwater - Channels or partial channels connected to the main channel at flows below the mean water level, but that are not tributaries. Chutes have throughflow at flows less than the mean water level whereas backwater features do not.

Snags - Woody debris located within the channel margins at or below the mean water level.

Control - A permanent or semipermanent structure or feature that impounds backwater.

Below the channel characteristics are spaces to note the stream type according to the classification proposed by Rosgen (1996) and for the stage of channel evolution according to Schumm et al. (1984).

The sixth category documents general geometric properties of the reach. Slope and planform characteristics of the reach are determined by field surveys for reference reaches, and interpretation of aerial photographs and USGS 7.5-min topographic maps for non-reference reaches. Mean widths and depths for the pool and riffle features are estimated in the field by the surveyors based upon random measurement of these features during the site investigation.

The seventh category documented on the field data collection sheets is the characteristics of existing protection structures. Insofar as such features were recognizable in the field, their location should be noted on aerial photos, mosaics, or other maps. Information regarding their character and dimension should be noted on the field data sheets. Four principal characteristics should be noted for each structure - type, height, length, and materials.

The eighth category addresses the bank characteristics that have a bearing upon the general stability and habitat conditions at the water/land interface. The streambank includes the land feature from top bank (as defined by the minimum ratio of the top width/area or the slope break on a rating curve for a section) to the toe. Included in this section are the height and slope of the upper bank, the soil material in the banks, a general assessment of the bank stability, and the vegetation cover. The listed parameters can be measured randomly, making estimates based upon visual observation and confirmed by the random measurements. Bank material may be difficult to ascertain because of the extent of vegetation cover. A description of the parameters follows.

Bank Characteristics:

Height - The distance (in feet) of the bank above mean high water (MHW). Heights are divided into ranges that include 0 – 4 ft, 4 – 8 ft, 8 – 12 ft, and greater than 12 ft.

Slope - The slope of the upper bank based upon visual inspection. Slopes are divided into ranges that include vertical, 1:1, 1:2 (1 ft vertical to 2 ft horizontal), and 1:3.

Bank Material - A general characterization of the soils found in the bank. No samples were collected and estimates were made on the basis of size classes as follows:

Unknown - Indeterminate due to vegetation or other cover.

Clay & Silt - Soil material smaller than 0.06 mm.

Sand - Soil material ranging in size from 0.06 to 2 mm.

Gravel - Soil material greater than 2 mm. A few reaches included small cobble material in limited areas and these were included in the gravel fraction.

Bank Status - A general characterization of the current erosional character of the bankline. Where more than one category applied for a given subreach, estimates were made of the percent distribution based upon longitudinal coverage. In some cases, more than one class applied to a given bank and two or more classes were checked without assigning percentages. A description of each class follows.

Protected - A manmade structure or feature is preventing erosion at the site.

Intact - No manmade structures are present or were apparent; bankline is stable.

Weathering - Soil loss is not occurring, but the structural integrity of the banks has been diminished by frost heave, freeze/thaw, piping, or geotechnical failure.

Eroding - Active erosion and bank retreat are occurring at the site.

Advancing - Deposition is occurring on the bank (associated with point bars).

Vegetation Types - An estimate of the coverage (in percent) of the banks of seven classes of vegetation. The vegetation classes are described above.

The ninth category documents the erosion conditions noted in each subreach. Two subcategories are addressed - the extent or location of the erosion and the mechanisms. The nature of the erosional processes in most watersheds is such that many contributory factors affect the erosion and determining which ones are at work in a given subreach is difficult with a limited observation and data collection effort. In particular, the normal sequence of channel evolution that accompanies development often overshadows other erosion processes.

Various visual indicators should be used to evaluate the types of failures. The "Bank Erosion" Technical Note (EMRRP-SR-21) in this series (Fischenich 1999) discusses the many factors that contribute to bank erosion and the visual indicators to determine which are predominant. Descriptions of the classes for the two subcategories follow.

Erosion Processes:

Extent

None - No erosion noted in the subreach (stable or accreting).

Toe - Erosion is limited to the toe zone of the bank.

Lower Bank - Erosion is occurring on both the toe and splash zones of the bank.

Upper Bank - Lower bank is intact, but geotechnical failures are occurring above the splash zone.

Whole Bank - Erosion and/or failure is occurring from the toe to the top of the bank.

Mechanism (See "Bank Erosion" section for a more complete discussion)

None - No erosion noted in the subreach (stable or accreting).

Flow Entrainment - Erosion occurring anywhere on the bank as a consequence of soil removal due to flow-induced shear stress.

Piping - Hydraulic and geotechnical failures on the bank above the toe zone as a consequence of groundwater flow removing lenses of soil from the bank.

Shallow Slide - Geotechnical failure on the entire upper bank resulting from oversteepening of a noncohesive bank as a consequence of degradation or removal of material from the bank toe.

Cantilever - Geotechnical failure on the entire bank resulting from removal of material from the bank toe and overburden on the upper or top bank.

Rotational - Geotechnical failure of the entire bank that results in mass wasting of bank material at the toe and a deep failure plane that is concave in shape.

Slab - Geotechnical failure of the top bank and mass wasting of material due to tension cracks in the top bank.

Other - Self explanatory.

The final category addresses the character of the channel substrate (sediments). Included are a general characterization of the sediments (percent distribution of each class) as well as the texture and sediment size based upon gradation analyses of select grab samples.

Environmental Assessment. The data collection and assessment sheets used to characterize each study reach include information in the header to identify the reach and the conditions under which it was surveyed (see Appendix B). In addition, a procedure based upon the EPA's Rapid Bioassessment

Protocols (RBP) is used to qualitatively assess the environmental condition. In the example sheet (for a watershed in Georgia), eight categories were used to assess environmental quality. These categories change with the location and objectives of each project.

All habitat parameters are evaluated and rated on a numerical scale of 0 to 20 (highest) for each of the reaches. The ratings are intended only to serve as a gross characterization based primarily upon subjective considerations. Reference conditions could be used to normalize the assessment to the "best attainable" situation, assuming an appropriate reference reach is identified. Descriptions of each parameter and its relevance follow. Decision criteria are given for each parameter, as shown on the example sheets in Appendices A and B.

1. Streambank Epifaunal Substrate/Available Overbank Cover: This includes the relative quantity and variety of natural structures in the stream, such as LWD, large rocks, and undercut banks, available as refugia, feeding, or sites for spawning and nursery functions of aquatic macrofauna. A wide variety and/or abundance of submerged structures in the stream provides the fish with a large number of niches, thus increasing habitat diversity. As variety and abundance of cover decrease, habitat structure becomes monotonous, fish diversity decreases, and the potential for recovery following disturbance decreases. Snags and submerged logs are among the most productive habitat structures for macro-invertebrate colonization in low-gradient streams.

2. Instream Substrate Characterization: Evaluates the type and condition of bottom substrates found in the reach. Firmer sediment types (e.g., gravel, sand) and rooted aquatic plants support a wider variety of organisms than a substrate dominated by sands and silts or silts and clays. In addition, reaches that have a uniform substrate will support far fewer types of organisms than a stream that has a variety of substrate types. Embeddedness refers to the extent to which rocks (gravel, cobble, and boulders) are covered by or sunken into the silt, sand, or clays of the stream bottom. Generally, as rocks become embedded, the surface area available to macro-invertebrates and fish (shelter, spawning, and egg incubation) is decreased.

3. Morphological Diversity of Channel and Flow: Diversity is a way to measure the heterogeneity of a stream. Riffles are a source of high-quality habitat and diverse fauna; therefore, an increased frequency of occurrence greatly enhances the diversity of the stream community. For areas where distinct riffles are uncommon, a measure of meandering or sinuosity helps define diversity. A high degree of sinuosity provides for diverse habitat and fauna. Diversity of depths and velocities protects the stream from excessive erosion during flooding and provides refugia for benthic invertebrates and fish. Natural conditions include reaches of moderately shifting channels and bends and stable reaches that do not exhibit progressive changes in slope, shape, or dimensions. Patterns of velocity and depth are included; the best reaches will have all four patterns present: (1) slow-deep, (2) slow-shallow, (3) fast-deep, and (4) fast-shallow.

4. Bank Vegetative Diversity and Condition Above Bankfull: Measures the amount of the streambank that is covered by vegetation. The root systems of plants growing on streambanks help hold soil in place, thereby reducing the amount of erosion that is likely to occur. This parameter supplies information on the ability of the bank to resist erosion as well as some additional information on the uptake of nutrients by the plants, the control of instream scouring, and stream shading. Banks that have full, natural plant growth are better for fish and macroinvertebrates than are banks without vegetative protection or those shored up with concrete or riprap. This parameter is made more effective by defining the natural vegetation for the region and stream type (i.e., shrubs, trees, etc.). In areas of high grazing pressure from livestock or where residential and urban development activities disrupt the riparian zone, the growth of a natural plant community is impeded. Residential developments, urban centers, golf courses, and rangeland are the common causes of anthropogenic degradation of the riparian zone.

5. Channel Stability (Base Level): This category addresses the stability of the channel profile in terms of the normal stage of evolution that channels undergo in response to urbanization. Channels that are actively headcutting (level 2), widening (level 3), or depositional (level 4) generally have degraded habitats when compared to naturally stable (level 1) or stable incised (level 5) channels. Of the three degraded conditions, level 2 stream segments generally offer the best habitat because they tend to have coarser substrates, greater pool depths and velocities, and more diversity, although the life of these features may be limited. Level 4 streams
tend to have the worst habitat conditions, but are on the way to recovery.

6. Bank Stability: Measures whether streambanks are eroded (or have the potential for erosion).

7. Riparian Vegetative Zone Width:
Measures the width of natural vegetation from the edge of the streambank out through the riparian zone. The vegetative zone serves as a buffer to pollutants entering a stream from runoff, controls erosion, and provides habitat and nutrient input into the stream. A relatively undisturbed riparian zone supports a robust stream system; narrow riparian zones occur when roads, parking lots, fields, lawns, bare soil, rocks, or buildings are near the streambank. The presence of minor paths and walkways in an otherwise undisturbed riparian zone was judged to be inconsequential to destruction of the riparian zone.

8. Riparian Management Potential:
Measures the need and attractiveness of preserving existing riparian habitat in a reach or of implementing management measures to improve riparian habitat.

FIELD OPERATIONAL RULES

During any field survey there are always numerous decisions to be made; they should be made in a consistent manner. The following operational rules will make field surveys easier by removing procedural ambiguities.

1. Minimum reach length is W_b (bank-full width).
2. Maximum distance along a channel without an assessment is 10 W_b (even if there is no change in the level of disturbance).
3. Reaches may be divided, as necessary, prior to the initiation of the reconnaissance, into shorter segments based on field examinations. The shorter reaches should be identified as a subset of the reach that is being subdivided (e.g., Reach 20 is broken into Reach 20.a and 20.b).
4. As in Rule 1, if a different *type* of channel is encountered it must extend for more than W_b to be included as a distinct subreach.
5. If a tributary, weir, or other feature that dramatically changes the stream character is encountered and the change extends for more than 3 W_b, then a new reach must be designated.
6. If a channel condition not considered or listed on the field data sheets is encountered, it should be added to the sheet for the reach in the notes section.
7. A preliminary reconnaissance of the watershed should be conducted to allow the surveyors an opportunity to formulate a sense of the range of environmental conditions present. Such an approval provides a general "reference" so the relative rankings of reaches will be preserved.
8. If a survey requires multiple modes of access (air, boat, wading, walking the banks), every effort should be made to access each reach with every means used for the study.

DATA ASSESSMENT

Companion technical notes in this series provide details on the potential uses of data collected following the guidelines outlined herein.

APPLICABILITY AND LIMITATIONS

Techniques described in this technical note are generally applicable to stream restoration projects that include fish habitat improvements as an objective.

ACKNOWLEDGEMENT

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> Fischenich, C. (1999). "Preliminary watershed assessment," *EMRRP Technical Notes Collection* (ERDC TN-EMRRP-SR-01), U.S. Army Engineer Research and Development Center, Vicksburg, MS. *www.wes.army.mil/el/emrrp*

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APPENDIX A
Reach Assessment - Physical

Stream _______ Reach _______ Lat/Lon _______/_______________ Sheet # _______
Date _________ Gauge _____ REF? Y N Surveyor _______________

Watershed
Area (sm) ___________
% Imp ______________

Adjacent Land Use (100 m)
Wetland ð
Forest ð
Agriculture ð
Parks & Recreation ð
Residential ð
Commercial/Ind. ð
Transportation ð
Utility ð

Riparian Vegetation (30 m)
Barren ð
Sedge & Grass ð
BLH ð
Shrub ð
Deciduous ð
Coniferous ð
Invasive ð
Non-Native ð

Cover (%)
Canopy ___________
LWD ___________
Other ____________
____
____

Channel Characteristics
Planform
Bend ð
Cross ð
Straight ð
Profile
Riffle ð
Pool ð
Run ð

Flow Type
Rapid ð
Tranq. ð
Features
Point Bars ð
Mid Bars ð
Shoals ð
Chutes/Backwtr. ð
Snags ð
Control ð
Slope (ft/mi) ___________
Notes: _______________
____
____

Stream Type ___________
CEM Stage ____________
Geometry
Slope
Valley ____________
Reach ____________
Riffle ____________
Pool ____________
Planform
λ ____________
Am ____________
Rc ____________
Pool Depth __________
Pool Width ___________
Riffle Depth ___________
Riffle Width ___________

Protection Characteristics
Type
Unprotected ð
Hardpoints ð
Revetments ð
Bioengineering ð
Grade Control ð
Other
Height ______________
Length ______________
Materials ______________

Bank Characteristics
Height Total @ Riffle (Ft.)
< 4 ð
4 – 8 ð
8 – 12 ð
> 12 ð
Bank Slope
Vertical ð
1:1 ð
1:2 ð
< 1:3 ð
Bank Material
Clay & Silt ð
Sand ð
Gravel ð
Cobbles ð
Bank Condition
Stable ð
Weathering ð
Eroding ð
Advancing ð
Vegetation Types (% Cover)
Barren Soil
Sedge & Grass
Shrubs
Deciduous
Coniferous
Invasive
Non-Native

Erosion Processes
Extent
None (Stable) ð
Bed ð
Toe ð
Upper Bank ð
Whole Bank ð
Predominant Mechanism
None ð
Flow Entrainment ð
Piping ð
Shallow Slide ð
Cantilever ð
Rotational ð
Slab ð
Overbank ð
Other

Substrate
Unknown ð
Clay & Silt ð
Sand ð
Gravel ð
Cobble ð
D50 (mm) __________
D84 (mm) __________
Texture __________

OTHER NOTES / SKETCHES: (Note Photo Numbers)

APPENDIX B
Reach Assessment - Environmental Characterization

Stream ______ Reach _______ Lat/Lon _____________/_____________ Sheet # _________

Date _________ Gauge ______ REF? Y N Surveyor ________________

Parameter	Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
1. Streambank Epifaunal Substrate/ Available Overbank Cover	Greater than 50% of SRH and IRH habitat on existing banks; presence of bars, snags, cut banks, gravel or other stable bank habitat at bank-full stage to allow full colonization potential.	SRH and IRH habitat on 5 to 50% of existing banks; mix of stable streambank habitat but not all types; well-suited for full colonization potential; adequate habitat for maintenance of populations.	Less than 5% useable SRH and IRH habitat; some mix of stable streambank habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 5% useable SRH and IRH habitat; lack of instream habitat diversity is obvious; substrate unstable or lacking.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Parameter	Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
2. Instream Substrate Characterization	Mixture of substrate materials, with gravel and cobbles prevalent; sand deposits are firm; several shoals and gravel bars; LWD > 10 percent; embeddedness minimal.	Mixture of sand and gravel with silts at margins; some shoals and gravel bars; emergent vegetation present or not; LWD > 10 percent; gravels and cobbles only slightly embedded.	Primarily sands and silts; few shoals or gravel bars; little emergent vegetation; LWD < 10 percent; gravels are highly embedded.	Shifting fine sands, silts and clays; no shoals or gravel bars; mostly runs; no emergent vegetation; little or no LWD; embeddedness not relevant.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Parameter	Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
3. Morphological Diversity and Flow Conditions	Predominantly riffles and pools; few tranquil runs; ratio of distance between riffles divided by width of the stream generally 5 to 10; variety of habitat is key; more than 4 distinct velocity/depth patterns present.	Approximately equal distribution of riffles, pools and runs; distance between riffles divided by the width > 10; more than three distinct velocity/depth patterns present.	Occasional riffle; tranquil runs > 25% of reach; pools associated with LWD; distance between riffles divided by the width of the stream >25; only 1 to 3 distinct velocity/depth patterns present.	Generally all tranquil runs; a few pools near LWD; poor habitat; distance between riffles divided by the width of the stream is a ratio of >25; dominated by one velocity/depth pattern.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Parameter	Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
4. Bank Vegetative Diversity and Condition Above Bank-full	More than 90% of the streambank surfaces covered by native vegetation, including trees, understory shrubs, and herbs; vegetative disruption minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one or more class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent.	50-70% of the streambank surfaces covered by vegetation; at least two classes of vegetation present; invasive species present; disruption obvious.	Less than 50% of the streambank surfaces covered by vegetation; only one class of vegetation; invasive species dominant; disruption of streambank vegetation is very high.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Parameter	Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
5. Channel Stability (Base Level)	Naturally stable; evidence of incision or bank failure absent or minimal; limited potential for future problems; CEM Level 1 or 5.	Stabilized; Grade control present and evidence of incision or bank failure absent or minimal; some potential for future problems; CEM Level 1, 4, or 5.	Moderately unstable; some entrenchment and/or impending entrenchment; long-term channel stability questionable; impending bank instability; any CEM level.	Unstable; entrenched; active headcuts; impending or active bank failures; any CEM level.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Parameter	Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
6. Bank Stability	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems; <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over; 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Parameter	Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
7. Riparian Vegetative Zone Width	Width of riparian zone >100 m for at least 90% of bankline; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone exceeds 30 m for at least 90% of bank length; human activities have impacted zone for less than 10% of banks.	Width of riparian zone less than 30 m for 10 to 50% of bank; human activities have impacted zone for more than 10% of banks.	Width of riparian zone less than 30 m for at least 50% of bank; little or no riparian vegetation due to human activities for at least 10% of banks.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Parameter	Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
8. Riparian Management Potential	Existing riparian habitat high quality; preservation of habitat likely with minimal management; affords opportunities for demonstrations and improvements.	Existing riparian habitat only slightly degraded; preservation and/or improvement likely with moderate management effort.	Existing riparian habitat somewhat degraded; preservation and/or improvement possible but would require significant management effort.	Existing riparian habitat degraded; preservation not desirable or attainable; improvement not likely or would require significant and costly management effort.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0